U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

PB-260 239

REPORT ON WATER DEMANDS, QUALITY CONSIDERATIONS AND PUBLIC HEALTH ASPECTS OF THE PROPOSED LYMAN PROJECT IN SOUTHWESTERN WYOMING

PUBLIC HEALTH SERVICE
DENVER, COLORADO

PREPARED FOR
BUREAU OF RECLAMATION

SEPTEMBER 1962

PB 260 239

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U. S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

BIBLIOGRAPHIC DATA SHEET	1. Report No.	2.	3. Recipient's Accession No. PB-260 239
4. Title and Subtitle Report on Water Demands, Quality Considerations and Public Health Aspects of the Proposed Lyman Project in Southwestern Wyoming.			5. Report Date Sep 62 6.
7. Author(s)			8. Performing Organization Rept. No.
9. Performing Organization Name and Address Public Health Service, Denver, Colo. Div. of Water Supply and Pollution Control.			10. Project/Task/Work Unit No. 11. Contract/Grant No.
12. Sponsoring Organization Name and Address Bureau of Reclamation, Salt Lake City, Utah. Region 4.			13. Type of Report & Period Covered 14.

15. Supplementary Notes Prepared in cooperation with Bureau of Reclamation, Salt Lake City, Utah. Region 4. Report on Colorado River Basin Water Quality Control Project.

16. Abstracts

Consideration is given to present and estimated future water demands, water quality considerations, and general public health aspects of the Bureau of Reclamation's proposed Lyman Project in southwestern Wyoming. The Lyman Project area is an integral part of the Colorado River Basin. Three areas are studied in this report: (1) the Lyman Project area, which would receive irrigation water; (2) Blacks Fork Basin, used for the evaluation of the water quality aspects; and (3) Bridger Valley, used for the economic analysis. Water requirements and use are reviewed along with vector-borne disease and related problems.

17. Key Words and Document Analysis. 17a. Descriptors

17b. Identifiers/Open-Ended Terms

*Water quality
Economic factors
*Public health
Hygiene
*Water reclamation
*Lyman Project
Colorado River
Wyoming
Blacks Fork Basin
Bridger Valley
Water supply

17c. COSATI Field/Group 13B

18. Availability Statement	19. Security Class (This Report) UNCLASSIFIED	21. No. of Pages 36
	20. Security Class (This Page) UNCLASSIFIED	22. Price

FORM NTIS-35 (REV. 10-73) ENDORSED BY ANSI AND UNESCO. THIS FORM MAY BE REPRODUCED USCOMM-DC 8265-P74

REPORT ON WATER DEMANDS, QUALITY CONSIDERATIONS AND PUBLIC HEALTH ASPECTS OF THE PROPOSED LYMAN PROJECT IN SOUTHWESTERN WYOMING

Prepared at the Request of and
in Cooperation with the Bureau of Reclamation
Region 4, U. S. Department of Interior, Salt Lake City, Utah

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Bureau of State Services
Division of Water Supply and Pollution Control
Region VIII
Denver, Colorado

Colorado River Basin Water Quality Control Project

September 1962

CONTENTS

	Page
SECTION A. BASIS FOR THE REPORT AND SUMMARY OF FINDINGS	A-1
Introduction	A-1
Summary	A-1
Recommendations	A-3
SECTION B. PHYSICAL DESCRIPTION OF THE PROJECT AREA	B-1
Location and Size	B-1
Physiography	B-1
Project Features	B-1
Land Use and Ownership	B-2
Soils	B-2
Climate	B-4
Hydrology	B-4
Transportation Facilities	B-6
SECTION C. PRELIMINARY ECONOMIC SURVEY	C-1
Introduction	C-1
Identification of the Study Area	C-1
Resource Utilization in the Local Economy	C-1
Summary of Current and Expected Future Economic Activity	C-5
SECTION D. WATER REQUIREMENTS AND USE	D-1
Present Water Use	D-1
Expected Future Water Use	D-2
SECTION E. WATER QUALITY CONSIDERATIONS	E-1
Present Status	E-1
Probable Future Situation	E-4
Stream Flow Regulation for Water Quality Control	E-5

SECTION F. VECTOR-BORNE DISEASE AND RELATED PROBLEMS F-1

Nature and Extent of Mosquito and Other Vector Problems F-1

Anticipated Effects of the Project on Vector Problems F-5

SECTION A. BASIS FOR THE REPORT AND SUMMARY OF FINDINGS

INTRODUCTION

Consideration has been given in this report to present and estimated future water demands, water quality considerations and general public health aspects of the Bureau of Reclamation's proposed Lyman Project in southwestern Wyoming. This study was initiated in accordance with the memorandum of understanding of September 28, 1956, between the Bureau of Reclamation Region 4, Department of Interior, and the Public Health Service, Region IX, Department of Health, Education, and Welfare. After a meeting of the two agencies at the Region 4 office of the Bureau of Reclamation on August 2, 1962 and subsequent discussions, the study was expanded to cover all areas of Public Health Service interest, and Public Health Service responsibility as set forth in section 2(b) of the Federal Water Pollution Control Act (Public Law 660, 84th Congress as amended by Public Law 87-88, approved July 20, 1961).

The Lyman Project Area is an integral part of the Colorado River Basin now under study by the Colorado River Basin Water Quality Control Project. One of the objectives of this basinwide effort is to develop a plan and program of comprehensive water quality management. The first phase of this study, a report for the Green River sub-Basin, which includes the Lyman Project area, is scheduled for completion during Fiscal Year 1964. Since the preliminary investigations covered in this report were made in advance of detailed field investigations to be carried out in support of the development of a comprehensive water supply and pollution control program for the Colorado River Basin, certain materials, conclusions, and recommendations contained in this report may require later revision.

Three areas are studied in this report: 1) The Lyman Project area, 2) Blacks Fork Basin, and 3) Bridger Valley. The Lyman Project area consists of the area to receive project irrigation water around Lyman, Wyoming. The Blacks Fork Basin was used for the evaluation of the water quality aspects. The Bridger Valley division was used for the economic analysis since this area includes the major portion of economic activity and is the smallest geographic subdivision of published census data.

SUMMARY

The Lyman Project, located in Uinta County, Wyoming, is one of the authorized projects of the Colorado River Storage Project. It is proposed as a means of improving the irrigation water supply of the area and thus improving its agricultural economy. No additional lands will be brought under irrigation as a result of the proposed project.

Construction features include the Meeks Cabin Dam and Reservoir on the Blacks Fork above Fort Bridger, the China Meadows Dam and Reservoir on the East Fork of Smiths Fork above Mountain View, and some ditching and lateral structures for more efficient distribution of irrigation water. Recreational facilities are planned for both of the reservoirs.

Under present conditions almost all of the 49,630 acres under irrigation suffer from inadequate water supplies during the latter part of the irrigation season. Under project operation, supplemental supplies would be made available for some 36,000 acres of the presently irrigated lands. A minimum flow of 10 and 8 cubic feet per second is to be provided below the storage reservoirs on Blacks Fork and East Fork of Smiths Fork respectively. In addition, the project is expected to result in an additional 49,000 acre-feet of water for irrigation diversion, including 13,100 acre-feet of irrigation return flow for use in the lower reaches of the project area.

Calcium carbonate is found at various depths in all virgin soils of the area but has disintegrated in most of the soils under irrigation. The surface layer of the residual soils, has a high concentration of lime.

The economy of the study area is almost entirely dependent upon agriculture at the present time and is not expected to change within the foreseeable future. Beyond 1980, however, as industrialization becomes more important to the economy of southwestern Wyoming, some increase in local non-agricultural activity is anticipated.

Irrigation is by far the dominant water use in the area. At the present time no water is being used for manufacturing or other industrial purposes. The Blacks Fork and its tributaries, except for Hams Fork, are not utilized for domestic water supplies at this time. Water for future municipal and industrial purposes will be available from Fontenelle Reservoir which is now under construction on the Green River. Storage of water for municipal and industrial purposes, therefore, does not appear warranted in this project. Individual ground water supplies obtained from deep wells are not expected to be affected by the project development. Future irrigation demands are expected to exceed available supplies, even with the project in operation.

The quality of the water of Blacks Fork and its tributaries, including Smiths Fork, above the presently irrigated area is satisfactory for municipal and industrial purposes. Above the irrigation return flow points, the total dissolved solids ranged from 50 to 135 parts per million; below the irrigation return flow points in the vicinity of Urie, the water is generally of poor quality as total dissolved solids ranged from 1,700 to 3,200 ppm. Below the confluence of Smiths Fork and Blacks Fork total dissolved solids range from 700 to 5,000 ppm. The effect of improved regulation of irrigation water as a result of project operation on total dissolved solid content in the stream below the irrigation return flow points cannot be determined without additional field investigation and evaluation.

Temporary construction camps will probably be required to serve employees during the construction phase of the project. Water supplies and sanitary facilities developed for this purpose should meet the standards required by the Wyoming State Department of Public Health.

On the basis of a preliminary evaluation of the probable future economy of the Lyman area, there appears to be little likelihood that downstream beneficiaries of water quality control will locate immediately downstream of the project area. Storage of water for flow regulation for quality control therefore does not appear warranted. Some 13,100 acre-feet of irrigation return flow water is expected to be reused for irrigation downstream from its return point and according to the Bureau of Reclamation, it is expected to be of suitable quality for reuse for this purpose.

Encephalitis, commonly known as sleeping sickness or brain fever, is now the most important mosquito-borne disease in the United States and in the area in which the proposed project will be located. Records of the U. S. Department of Agriculture show that equine encephalitis cases have occurred in Uinta County, Wyoming. Natural breeding places occur in most irrigated areas, but usually the man-made mosquito sources are frequently caused by the same faulty irrigation and drainage practices that cause serious soil and water problems such as excessive water losses, water logging, erosion, salt and alkali accumulations, damage to soil structure, leaching of plant nutrients and reduced crop yields. Every effort should be made to encourage farmers to use improved irrigation and drainage methods to prevent and minimize mosquito sources.

RECOMMENDATIONS

Quality and quantity aspects cannot be artificially separated when planning for optimum development of an area's water resources. Since many diverse interests in the project area are involved, it is essential that water resource development aspects that pertain to the general health and welfare of the project impact area are coordinated with Federal, state and local health department requirements. To minimize the potential damage to the health and welfare of the project impact area that may be associated with the development of the Lyman Project, it is recommended that the following be given due consideration:

1. The water users organization operating as the general administrative and contracting agency for the proposed project should be advised of the services and information available from local and state health authorities in order that these services may be utilized by their project residents.

2. All construction camps should be provided with at least minimum water and sanitary facilities in accordance with State and local health department requirements.

3. All recreational areas should be provided with at least minimum water and sanitary facilities in accordance with State and local health department requirements. Wherever possible precautionary measures should be taken to prevent formation of recreational

areas without provisions being made for a safe water supply and adequate sanitary facilities.

4. All effort should be extended during construction stages, including land leveling and clearing, to exclude excess silt and debris from surface waters.

5. The Wyoming and Utah State Departments of Health should be kept currently informed regarding changes in plans and proposed construction schedules so that guidance and consultation may be provided on public health problems that may be encountered.

6. At this time, no storage be planned in project reservoirs for purposes of water quality control because there are no apparent future users that require higher quality water.

7. Recommendations relating to vector control:

In order to minimize public health hazards, every possible effort should be made to avoid creating conditions which will increase populations of mosquitoes and other arthropods and rodents of public health importance. It is recommended that the following principles and practices be adhered to in the design, construction, operation, and maintenance of the proposed project.

Responsibility for Vector Control

Responsibility for vector prevention and control is normally associated with land ownership or operating rights. Therefore, the agency, group, or individuals responsible for various aspects of the proposed project should be prepared to accept full responsibility for the prevention and control of vector problems resulting from the design, construction, operation or maintenance of the project.

Prevention and Source Reduction Measures

Mosquitoes and Other Aquatic Insects

A. Reservoirs

1. Prior to impoundage, the reservoir basins should be prepared as follows:

   a. The normal summer fluctuation zone of the permanent pool should be completely cleared except for isolated trees and sparse vegetation along abrupt shorelines or in the deeper portions of the pool which will be exposed to wave action.

   b. All depressions, marshes, borrow pits, and sloughs which will be

flooded by the reservoir at maximum pool level and which will retain water at lower pool levels should be provided with drains to insure complete drainage or fluctuation of water within them.

2. After impoundage, the following maintenance measures should be carried out in all potential mosquito-producing areas located within flight range of human population groups or recreational areas frequented by significant numbers of persons:

   a. All dense vegetation should be removed periodically from flat, protected areas within the normal summer fluctuation zone of the permanent pool.

   b. Vegetation, debris, and flotage should be removed periodically from all drains to insure free flows.

3. Water level management to minimize conditions favorable for mosquito production should be used to the maximum degree permitted by the primary purposes of the reservoirs. This will minimize the need for repetitive measures for controlling vegetation and mosquito production.

4. As a general principle, waterside recreational areas, particularly those which have facilities for overnight occupancy, should be located along sections of reservoirs which have a low production potential for mosquitoes and other aquatic insects.

B. Project Irrigation Conveyance and Distribution System

1. Lining or other satisfactory seepage control measures should be provided for all sections of canals and laterals located in porous material where excessive leakage would result in waterlogged areas, seeps, and ponds.

2. Drains should be installed to prevent ponding of excess irrigation water and natural runoff along the upper side of canals and laterals. All drainage crossing or inlet structures should be placed on grade to avoid ponding.

3. All borrow areas should be self-draining to keep them from retaining ponded water.

4. Where possible, provision should be made to prevent turnouts and other hydraulic structures from retaining residual water when they are not being used.

5. Effective measures should be provided to prevent ponding of leakage from water control structures.

6. Vegetation and debris which retard normal flows should be periodically removed from all conveyance channels, water control structures, and drains.

C. Project Drainage Systems

1. Trunk drainage systems should be installed to insure complete removal and proper disposal of excess irrigation water, natural runoff, and seepage from both irrigable and nonirrigable lands affected by the distribution and use of irrigation water on the project.

2. Drainage ditches should be designed, constructed, and maintained so as to minimize ponding in the channels and to insure free flows at all times.

3. Provision should be made to prevent water from ponding behind spoil banks.

4. Underdrains, culverts, inlets, etc., should be placed on grade to prevent ponding.

D. Irrigated Farms

1. The farm supply system, drainage system and field layout should be properly fitted to the topography, soil, water supply, crops to be grown, and irrigation methods to be used.

2. All surface irrigated fields should be properly leveled or graded to provide for efficient water application and removal of excess water without ponding.

3. An adequate drainage system should be provided for removal of excess water from all portions of the farm.

4. Irrigation methods should be used which will provide optimum irrigation efficiencies

5. Application of irrigation water should be limited to that required to fill the crop root zone plus unavoidable losses and excess water to prevent upward movement of salts.

6. Cultural and soil management practices that will develop and maintain good soil structure and infiltration rates should be utilized to the fullest extent possible.

Terrestrial Arthropods and Rodents at Recreational Areas Associated with Reservoirs

1. Proper storage, collection, and disposal of refuse should be practiced in order to prevent and control flies, wasps, other noxious insects, rats, wild rodents, and other small mammals.

2. All buildings should be rodentproofed at recreational areas where rodents are prevalent which may create public health hazards.

3. Debris, rubbish, and other materials which may serve as harborage for rodents and other small mammals should be removed periodically.

4. Brush and weeds along paths, trails, roadways, and other areas of frequent use by visitors should be removed in order to reduce the likelihood of tick infestation.

Supplemental Chemical Control Measures

In situations where adequate vector control is not obtained through the prevention and source reduction measures outlined above, provision should be made for supplemental use of insecticides and rodenticides to achieve the desired level of control.

SECTION B. - PHYSICAL DESCRIPTION OF THE PROJECT AREA

LOCATION AND SIZE

The potential Lyman project, located entirely in Uinta County in southwestern Wyoming, is authorized as one of the participating projects of the Colorado River storage project. The project area is located within the upper part of the Green River Sub-Basin of the Colorado River Basin and is centered about 40 miles east of Evanston, Wyoming. The Lyman area, generally known as Bridger Valley, extends from the foothills of the Uinta Mountains northward for about 25 miles.

PHYSIOGRAPHY

Blacks Fork and its tributaries, which would provide the project water supply, are bordered on the west by the Bear River drainage basin and on the east by the Henrys Fork watershed. Blacks Fork and its tributaries originate high in the Uinta Mountains in Utah and drain the central portion of the mountains' northern slope. From their headwaters the streams flow in a northerly and easterly direction for about 75 miles, thence east and south for about 40 miles to the Green River.

PROJECT FEATURES

The Lyman project is contemplated primarily as a means of improving the study area's irrigation water supply and thus bettering agriculture production on lands near the town of Lyman, Wyoming, in Bridger Valley. The project plan proposes two reservoirs for storing and regulating the flows of Blacks Fork and Smiths Fork to provide supplemental water supplies to 36,000 acres of the 49,630 acres of presently irrigated land. Inadequate water supplies and soil deficiencies do not permit service to all presently irrigated land.

Meeks Cabin Dam and Reservoir on Blacks Fork of 33,000 acre-feet capacity would be located in Wyoming about 36 road miles southwest of Fort Bridger, Wyoming. With an active capacity of 30,000 acre-feet, this reservoir would increase usable water supplies by an average of about 37,400 acre-feet, about 10,400 acre-feet of which would come from reuse of return flows.

China Meadows Dam and Reservoir on East Fork of Smiths Fork of 13,000 acre-feet capacity would be located in Utah about 25 road miles south of Mountain View, Wyoming. With an active capacity of 11,000 acre-feet, of which 10,000 acre-feet would be utilized for irrigation, this reservoir would increase usable water supplies by an average of about 11,600 acre-feet, about 2,700 acre-feet of which would be from the reuse of return flows. Approximately 1,000 acre-feet of the active storage in China Meadows Reservoir will be used to replace existing storage rights in Marsh and China Lakes and to maintain minimum flows in East Fork of Smiths Fork and thus improve fishing values in these areas of the watershed.

Recreation facilites are planned for all reservoirs. Consideration is also being given to providing small fish ponds, about five feet deep, at about one-half mile intervals in the first 10 miles of the Blacks Fork ~~River~~ below the Meeks Cabin Dam and Reservoir.

Project water will be distributed through existing ditches and laterals. It is not expected that water users will undertake extensive land leveling or ditch improvement work, but some improvements in farm application efficiency is expected from the additions of some ditch and lateral structures and from close control in the distribution of water. The project, however, does not plan to provide any drainage facilities.

The Upper Colorado River Basin Compact of 1948 sets forth the basis for ultimate division of that portion of the water supply covered in the Colorado River Compact of 1922. The project plan contemplates a more efficient use of available irrigation water. Development of the Lyman project will result in a reduction in flow of the Blacks Fork by an estimated annual depletion of 9,800 acre-feet due to increased consumptive use on project land, but this is still within Wyoming's alloted share under Upper Colorado River Basin Compact. The project will not interfere with other potential projects utilizing the water resources of the Colorado River Basin.

LAND USE AND OWNERSHIP

The project development area lies entirely within Uinta County, Wyoming. A summary of land ownership for the county and the project area is shown in Table B-1. Approximately 58 percent of the county and 31 percent of the project area is in private ownership. Federal lands account for only 38.4 percent of the county but 64.5 percent of the project area. State and local ownership was estimated to be 3.9 percent of the county and 4.6 percent of the project area.

Approximately 86 percent of the 1,200 square mile land area in Uinta County is devoted to grazing and mineral reservations. Approximately 8 percent is presently used for irrigated crop production. Almost 6 percent of the county land area is included in the Wasatch and Ashley National Forests.

SOILS

Soils of the Lyman project area are not deeply weathered since they were developed under the influence of a semiarid climate. Three major groups of soils are found: 1) Alluvial soils in narrow bands along the major stream; 2) terrace soils on benches adjacent to the alluvial soils; and 3) residual soils formed on ridges of the higher elevations. Calcium carbonate is found at various depths in all virgin soils but has disintegrated in soils under irrigation.

The alluvial soils include the Havre and Logan Series and are moderately calcareous in their native state. These are found primarily along Blacks

Table B-1. Land Ownership in Uinta County, Wyoming and in the Lyman Project Area, 1958.

Type of Ownership	Uinta County		Lyman Project area 1/	
	acres	percent	acres	percent
Private	764,968	57.7	189,120	30.9
State and Local 2/	50,899	3.9	28,160	4.6
Federal	508,933	38.4	394,300	64.5
Bureau of Land Management	463,974	35.0	348,460	57.0
National Forest	36,880	2.8	45,840	7.5
Other	8,079	.6	---	--
Total	1,324,800	100.0	611,580	100.0

1/ Includes Wyoming's portion of the Lonetree area, Henrys Fork drainage. Estimate of this acreage not available.
2/ Includes county, municipal, highway rights-of-way, etc.

Source: Land Ownership in Wyoming Counties, 1958, Information Circular #3, Division of Business and Economic Research, College of Commerce and Industry, University of Wyoming, Laramie, Wyoming. Revised 1960 and unpublished data obtained from Mr. Richard Bakalar, Work Unit Conservationist, Soil Conservation Service, U.S.D.A., Mountain View, Uinta County, Wyoming.

Fork and Smiths Fork. Textures vary from sandy loam to clays. Gravel and cobble stones are common on the surface and at varying depths. In general, these soils are permeable and possess a fairly good water-holding capacity.

Benchlands consisting of terrace soils classified in the Ashuelot and Avon Series, are found between Blacks Fork and Smith Forks and in limited amounts east of Smiths Fork. The surface horizon consists of a capping of gravel and cobble ranging in depth from a few inches to 15 feet. Underlying the surface layer are various formations including shale, mudstones and sandstones.

Areas of residual soils, primarily the Cut Bank and Shavano Series, occur to the west of Blacks Fork, north of Millborne and at several locations in Bridger Valley. The surface layer, commonly 8 to 12 inches in depth and of a sandy loam texture, has a high concentration of lime which leaches readily under irrigation. The substratum contains considerable lime.

CLIMATE

The Lyman area has a cool semiarid climate with freezing temperatures having been recorded in every month of the year. The average period between frosts is commonly about 92 days. Although the mean annual temperature is 41 degrees F, extremes ranging from 37° F below zero to a high of 102° F have been recorded. Precipitation normally averages about 10 inches and is more or less equally distributed throughout the year. High winds are common which accounts for high evaporation rates in spite of the temperatures. A summary of average climatological data for the Lyman study area is shown in Table B-2.

HYDROLOGY

The discharge of Blacks Fork and tributaries, which would provide project water, has wide annual and season fluctuations. Runoff from rapidly melting snow exceeds the capacity of existing diversion canals during the early irrigation season, while irrigation requirements exceed the available streamflow later in the season. Table B-3 shows the period of record and maximum, minimum and average stream flows at selected stations during the period.

The basic plan of development of the Lyman project consists of construction of facilities to store non-irrigation flows and the excess spring runoff. Regulated release of stored water will provide a supplemental water supply during the latter part of the irrigation season for about 36,000 acres of project lands.

Under the proposed project plan a minimum flow of 10 cfs would be maintained in the Blacks Fork below Meeks Cabin Dam and a minimum of 8 cfs would be maintained in the East Fork of Smiths Fork below China Meadows Dam.

Other gaging stations are included in Table B-3 in order that comparisons in the area may be made. Note the dilutional effect of the Green River on flows from Blacks Fork.

Table B-2. Summary of Average Climatological Data for the Lyman Project Area in Southwestern Wyoming. 1/

Annual precipitation (inches)	10.0
Growing season precipitation (inches)	5.7
Effective growing season precipitation (inches)	2.0
July mean temperature (degrees Farenheit)	66.2
January mean temperature (degrees Farenheit)	18.0
Average annual temperature (degrees Farenheit)	41.0
Coldest temperature recorded (degrees Farenheit)	-37.0
Hottest temperature recorded (degrees Farenheit)	102.0
Frost-free period (June 10 to September 10) (days)	92

1/ Averages computed on the basis of data gathered at the Lyman and Fort Bridger weather stations.

Table B-3. Summary of Streamflow Data near the Lyman Project Area in Southwestern Wyoming.

U.S.G.S. Gaging Stations	Period of Record	Flows			
		Maximum cfs	Minimum cfs	Avg.over Pd. of Record (cfs)	(ac.-ft. per yr.)
Green River near Green River, Wyo. 1/	1951-60	14,600	170	1,614	1,168,000
Blacks Fork near Millburne, Wyo. 2/	1939-60	2,530	20	155	112,200
East Fork of Smiths Fork near Robertson, Wyo. 3/	1939-60	1,200	7/	44.4	32,140
West Fork of Smiths Fork near Robertson, Wyo. 4/	1939-60	920	0.2	19.8	14,330
Blacks Fork near Green River, Wyo. 5/	1947-60	5,500	0	313	226,600
Green River near Greendale, Utah 6/	1950-60	19,600	208	2,133	1,544,000

1/ One mile southeast of town of Green River. Flow affected by transmountain diversions, storage reservoirs, power development, irrigation diversions, irrigation return flows.
2/ Fifteen miles southwest of Millburne. Diversions above station for irrigation.
3/ Nine miles southeast of Robertson. No diversions above station.
4/ Twelve miles southwest of Robertson. No diversions above station.
5/ Twelve and one-half miles southwest of town of Green River and about 14 miles above mouth. Diversions above station to irrigate about 114,000 acres. 18 small reservoirs above station.
6/ Half mile downstream from Flaming Gorge Dam. Diversions above station for irrigation and raw water supplies for municipal and industrial uses.
7/ Not determined.

TRANSPORTATION FACILITIES

The Lyman area is favorably located in regard to major transportation facilities. U.S. Highway 30 traverses the area and serves as the major transportation outlet. A branch of the Union Pacific Railroad skirts the western edge of the project area. In addition, an 8 inch oil pipeline of the Pioneer Products Company and a 13 inch gas pipeline of the Mountain Fuel Company pass through the area. Local secondary road facilities tend to be somewhat limited and many of them are still unimproved.

SECTION C. PRELIMINARY ECONOMIC SURVEY

INTRODUCTION

This section of the report contains an initial analysis of the present and probable future economy of the Lyman Project area in Uinta County, Wyoming. The study area is included in an overall economic base survey of the Green River sub-Basin now underway as a part of the comprehensive water quality management study by the Colorado River Basin Water Quality Control Project. The findings of this study, scheduled for completion during fiscal year 1964 may require revisions in the preliminary economic evaluations presented below.

IDENTIFICATION OF THE STUDY AREA

The economic study area is primarily limited to the Bridger Valley Division of Uinta County, Wyoming as delineated by the Bureau of Census, U. S. Department of Commerce and because this area includes the major portion of economic activity. The geographic extent of this area is too small to allow for adequate consideration of external factors affecting its probable future growth. These preliminary findings, therefore, can serve only as a general guide to local development possibilities.

RESOURCE UTILIZATION IN THE LOCAL ECONOMY

The resource base of the Lyman project area provides limited opportunities for future development. Past development as well was hampered by a shortage of available resources. Irrigation, for example, is dependent upon spring runoff and therefore suffers from a shortage during the late season irrigation period.

Resource-oriented activity in the study area is limited almost solely to agriculture. No mining or manufacturing firms are in operation at the present time. Recreational activity is present to a limited degree and some activity attributable to through-travelers is in evidence.

POPULATION CHARACTERISTICS

The last population increase in the study area occurred during the 1930-1940 decade. A moderate decline in population has continued from 1940 to date (Table C-1). Under the definition in use by the Bureau of the Census, all of the area's population is classified as rural.[1/] According to available population projections, almost no increase in population is expected to the year 1980.[2/]

1/ Includes all towns of less than 2,500 population.

2/ Population projections prepared for Wyoming counties, 1950-1980, by the Division of Business and Economic Research, College of Commerce and Industry, University of Wyoming, Laramie.

Table C-1. Population Distribution by Census Enumeration Units, Lyman Project and Uinta County, Wyoming, 1940-1960[1/]

County Divisions and Sub-divisions	Lyman Project Area				Uinta County			
	1930	1940	1950	1960	1930	1940	1950	1960
Bridger Valley Division								
Lyman town	377	378	483	425	377	378	483	425
All other rural	1,818	2,002	1,566	1,533	1,818	2,002	1,566	1,533
Total	2,195	2,380	2,049	1,958	2,195	2,380	2,049	1,958
Evanston Division								
Evanston town	--	--	--	--	3,075	3,605	3,863	4,901
All other rural	--	--	--	--	1,302	1,238	1,419	625
Total	--	--	--	--	4,377	4,843	5,282	5,526
Grand Totals	2,195[2/]	2,380[2/]	2,049[2/]	1,958	6,572[2/]	7,223[2/]	7,331[2/]	7,484

1/ Refer to U. S. Department of Commerce, Bureau of Census, United States Census of Population: Wyoming, 1960, "Number of Inhabitants," PC(1) 52A, page 52-4 for a map of the Census county divisions.

2/ County census divisions were changed in the 1960 Census of Population, therefore for 1930, 1940 and 1950 Census division districts 1,2,3,4 and 5 were combined to form the Evanston Division and Census division districts 6,7,8,9, 10, 11 and 12 were combined to form the Bridger Valley Division.

Source: U. S. Census of Population

LABOR FORCE CHARACTERISTICS

It was estimated that the labor force experienced a decline of 14 percent from 1950 to 1960. The unemployment rate of 3.4 percent recorded in 1960 shows almost no change from that experienced in 1950. Out of an average employed labor force of 650 persons in 1960, approximately 35.4 percent were engaged in agriculture, 3.1 percent in manufacturing, and 61.5 percent in other miscellaneous commercial activities. 1/ The employment distribution is expected to remain relatively unchanged through 1980. Agricultural employment is expected to level off at about one-third of the labor force and slight increases are anticipated in services and trades catering to tourists and other thru-travelers.

AGRICULTURE AND FORESTRY

Irrigated agriculture, dating from about 1862, is the most important economic activity in the study area. Feed production in support of livestock, primarily forage crops, has predominated through the years (Table C-2). This type of cropping pattern has been developed due to the limitations of a short, relatively cool growing season, and the remoteness to markets for cash crops. On-farm pastures are supplemented by summer grazing on National Forest and Bureau of Land Management lands. Part-time farming is prevalent in the area; during 1960, approximately 50 percent of the farm operators supplemented their income with off-farm employment.

Agriculture is expected to remain the dominant industry in the study area and the farm population is expected to remain more or less stable at the present level. A slight decline in irrigated acreage is anticipated in 1980. The cropping pattern is expected to remain unchanged. Some expansion in the use of National Forest lands is anticipated. This will likely involve increased recreational activity and timber production. Granger, Wyoming, located downstream from the project area, has been considered as a likely site for a pulp mill but this development is not expected to occur before 1980.

MINERALS

The Lyman Project is practically devoid of mineral deposits. Oil and gas deposits have been discovered but have not been utilized to date. Some deposits of coal and sulphur are known to occur but these are not considered of major economic significance 2/. Mineral production is therefore not expected to have any impact on the future economy of the study area.

MANUFACTURING

Manufacturing has never been an important segment of the local economy nor is it expected to increase significantly in the near future. Westvaco's trona plant a few miles northeast of the town of Lyman currently draws some of its labor force from the project area and some expansion of production is anticipated. In addition, there may be some increased activity if a pulp mill is located in the area in the distant future as mentioned above. It is assumed that any future water demands for industrial development downstream of the project area will be met from State purchased water stored in Fontenelle Reservoir now under construction on the Green River, north of the project area.

1/ U. S. Census of Population.

2/ R. E. Lund, A Study of the Resource, People, and Economy of Southwestern Wyoming, (Draft for Criticism and Review) Division of Business and Economic Research, College of Commerce and Industry, Univ. of Wyo., Laramie, Wyo., Jan. 1962.

Table C-2. Irrigated Land Use, Lyman Project, Wyoming, 1950 and 1958. 1/

Crop	1950		1958	
	acres	percent	acres	percent
Alfalfa	2,402	6.0	1,983	6.2
Wheat	701	1.8	none	--
Barley	2,361	5.9	81	.3
Oats	2,765	7.0	301	.9
Sunflower silage	none		107	.3
Rotation pasture	6,398	16.1	306	.9
Meadow hay land	5,430	12.7	12,992	40.3
Permanent pasture	18,900	47.6	15,984	49.6
Potatoes	262	0.7	none	--
Farmstead & Others	481	1.2	464	1.5
Totals	39,700	100.0	32,218	100.0

1/ Does not account for all irrigated land in the project area. According to the Bureau of Reclamation, the total irrigated acreage approximates 50,000 acres.

OUTDOOR RECREATION

Present recreational activity in the Lyman project area is limited primarily to fishing and hunting in and near the Uinta Mountain range. Tourists and other travelers moving through the study area on U.S. Highway 30 add significantly to the area's source of basic income. Their impact is concentrated primarily in service station sales and motel receipts. Future development in activities oriented to recreation is likely. 1/ The area has not kept pace with the rest of southwestern Wyoming in developing tourist facilites and it is therefore anticipated that an effort will be made to expand this source of basic income.

SUMMARY OF CURRENT AND EXPECTED FUTURE ECONOMIC ACTIVITY

The study area's economy is dependent almost entirely upon agricultural production at the present time and this is expected to continue to 1980. Approximately 50 percent of the farm operators supplement their income from off-farm employment. A slight decrease in irrigated acreage is expected to occur by 1980 but the farm population level is expected to remain more or less unchanged. Overall population is likewise to remain more or less constant at the present level.

Present employment opportunities in and near the study area are limited --a tourist service center at Little America, Wyoming, Westvaco's trona plant, a few sawmills, road construction and some local business. No major increase in the various sectors of the local economy appear feasible to the year 1980. Beyond 1980, as industrialization becomes more important to the economy of southwestern Wyoming. some increase in local economic activity can be anticipated, but water demands that may develop beyond 1980 are expected to be met from Fontenelle Reservoir. This activity will likely include a pulp mill at Granger, some manufacturing, and continued expansions of those businesses dependent upon tourists and other travelers.

1/ Personal interview with staff members of the Division of Business and Economic Research, University of Wyoming, Laramie, August 29, 1962.

SECTION D. WATER REQUIREMENTS AND USE

PRESENT WATER USE

Irrigation is by far the predominant water use in the project area. Public water supplies constitute a small use due to a relatively low population density. At the present time no water is being used for manufacturing or other industrial purposes.

PUBLIC WATER SUPPLIES

No towns in or adjacent to the project area utilize the Blacks Fork or Smiths Fork as a source of domestic water supply. Water supplies within the general vicinity of the potential project are summarized in Table D-1.

Table D-1. Public Water Supplies in the Blacks Fork Basin near the Lyman Project Area, Wyoming

Community	Source	Est. Population Served	Treatment	Remarks
Ft. Bridger	Indv. wells	--	None	--
Granger	Well	120	Chlorination	--
Kemmerer	Hams Fork	2900	Chlorination, filtration	Also serves Diamondville & Frontier
Lyman	Springs	483	Chlorination	--
Mt. View	Well	400	None	--

In general, individual water supplies are obtained from wells that are developed at a depth of approximately 50 feet. A few deeper wells have been developed resulting in artesian flows. There are several springs in the area. Shallow wells, producing water of poorer quality, may be developed at depths of about 15 feet.

IRRIGATION WATER USE

One of the first water rights in Wyoming was a territorial permit for an irrigation diversion from Blacks Fork which was issued in 1862. Over time, rights to use water in Blacks Fork and Smiths Fork and their tributaries have been adjudicated for the irrigation of 82,380 acres, approximately 82,000 acres of which are located in the Lyman Project area. The adjudication permits diversions at the rate of approximately 1 second-foot of water for each 70 acres of land under irrigation. The period of use, however, was not defined. The Bureau of Reclamation estimates that about 50,000 acres are actively under irrigation. 1/

1/ Approximately 34,100 acres are irrigated from the Blacks Fork and minor tributaries and 15,530 acres are irrigated along the valley formed by the Smiths Fork.

No records have been maintained of past water uses in the project area. Data are available, however, on total depletions occurring in the project area and these may be used to give a rough approximation of average annual irrigation use. On the basis of the difference recorded at gaging stations below the mouth of Smiths Fork on Blacks Fork near Lyman and records available for above the head of these irrigation lands, a present depletion of 64,200 acre-feet is indicated. Since irrigation currently practiced is dependent upon natural stream runoff, most of this diversion occurs during the period of spring runoff. This results in overirrigation during the early part of the irrigation season and extreme shortages during the later season irrigation period. Present water supplies would average only 50 percent of a full supply, based on an ideal demand. Only about 3,000 acres presently under irrigation would receive a full supply.

EXPECTED FUTURE WATER USE

Expected future water use from supplies developed by the Lyman Project will be limited primarily to irrigation. Future municipal and any industrial water supplies are not expected to be taken from Smiths Fork or Blacks Fork below the project area, but are expected to be supplied by Fontinelle Reservoir. Irrigation demands are expected to exceed supplies, even after the Lyman Project is put into operation. The project is expected to supply almost 50,000 acre-feet of additional irrigation water for some 36,000 acres of potential project lands, (Table D-2). Non-project lands would continue to receive direct diversions. Based on the Blaney-Criddle method of analysis, the Bureau of Reclamation has estimated that an annual diversion of 4.7 acre-feet will be needed per acre of crop production in the Blacks Fork area and 4.4 acre-feet per irrigated acre will be required in the Smiths Fork area.

Table D-2. Summary of Project Water Supply, Proposed Lyman Project

Reservoir	Active Irrigation Capacity	Average Annual Increase in Irrigation Diversions (Acre-Feet)		
		Storage Releases	Increased Return Flow	Total
Meeks Cabin on Blacks Fork	30,000	27,000	10,400	37,400
China Meadows on Smiths Fork	10,000	8,900	2,700	11,600
Project Totals	40,000	35,900	13,100	49,000

SECTION E. WATER QUALITY CONSIDERATIONS

PRESENT STATUS

SURFACE WATER SITUATION

The quality of the water of Blacks Fork and its tributaries above the presently irrigated area is considered satisfactory for municipal and industrial purposes. Chemical quality data pertaining to the surface waters appear in Table E-1 and E-2. Data from the Bureau of Reclamation indicate that the total dissolved solids of Blacks Fork water ranges from about 50-135 ppm 15 miles southwest of Millburne above irrigation return flows, whereas near Urie, about 10 miles below Millburne and below irrigation return flows, the water is generally of poor quality as total dissolved solids range from about 700 to 3,200 ppm. Below the confluence with Smiths Fork the total dissolved solids in the Blacks Fork range from about 700 to 5,000 ppm. The maximum determined total dissolved solids in Smiths Fork Creek water above Robertson was 159 ppm. In general, water of good chemical quality is available in the Blacks Fork above Millburne and in Smiths Fork above Mountain View.

Some small areas in the bottom lands contain large salt concentrations on the surface. Lands northeast and southeast of Lyman are high in soluble salts which are believed to result from the shale strata that underlies the soil. Proper application of irrigation water and drainage measures would tend to remove some of these salts. Return flows from presently irrigated lands in these areas are reflected in the total dissolved solids ranging from 671 to 4,912 ppm on samples collected from Blacks Fork Creek near Lyman.

GROUND WATER SITUATION

The potential project development is not expected to be detrimental to ground water supplies now utilized for domestic purposes in the project area.

SEWAGE DISPOSAL

In general the individual open country and town homes are equipped with modern plumbing and utilize septic tanks and subsurface disposal of waste waters where the public sewers are not available. It is estimated that about 25 percent of the homes do not have satisfactory waste disposal systems. Good subsoil drainage is encountered in the area, with the exception of some bottom land areas and on low benches where the impervious shale strata is close to the surface and natural drainage channels do not exist.

Municipal waste disposal facilities for the communities in and adjacent to the project area having public waste collection systems are summarized in Table E-3.

Table E-1. Chemical quality of surface waters* in the Lyman Project Area

Concentration (ppm)	Blacks Fork near Millburne[1] 4/59-10/61 (22)	Smiths Fork: East Fork near Robertson[2] 4/59-2/61 (20)	Smiths Fork: West Fork near Robertson[3] 5/59-10/61 (19)	Smiths Fork: Near Robertson 4/59-5/59 (2)	Smiths Fork: Near Mt. View 5/59-3/61 (21)	Blacks Fork: Near Urie 4/59-3/61 (25)	Blacks Fork: Near Lyman 4/59-3/62 (33)
Dissolved solids	135 24	85 20	159 25	116 99	472 152	3,158 716	4,912 671
Hardness (Computed)	127 20	67 13	120 18	92 82	216 87	1,545 354	1,709 269
Calcium	36 5	25 5	36 6	27 25	63 22	395 82	386 72
Magnesium	9 1	4 0.1	7 0.6	6 4	14 7	136 36	182 21
Sodium	4 1	3 1	5 1	7 5	81 15	327 90	773 96
Chlorides	2 0	1 0	28 0	4 3	73 10	102 30	183 46
Sulfates (Computed)	20 2	16 0	15 1	19 11	153 16	1,760 276	2,961 232

* Data from Bureau of Reclamation, Region 4. Number in parenthesis represents number of samples. Maximum and minimum values shown.

1/ 15 miles southwest.
2/ 9 miles southeast.
3/ 12 miles southwest.

Chemical quality and river flows--select stations* near the Lyman Project Area

Concentration[1] (ppm)	Green River near Green River, Wyo.[2] 10/56-9/57	Green River near Green River, Wyo.[2] 5/51-9/57	Blacks Fork near Marston, Wyo.[3] 11/56-9/57	Blacks Fork near Marston, Wyo.[3] 3/51-9/57	Green River near Greendale, Utah[4] 10/56-9/57
Dissolved solids	740	855	2,360	4,480	730
	164	159	345	278	237
	279	-	519	-	359
Hardness	383	420	950	1,980	400
	118	114	156	48	143
	170	-	262	-	203
Calcium	90		213		100
	28		57		40
	45		72		-
Magnesium	40		106		33
	9		14		11
	14		20		-
Sodium	97		397		111
	12		40		20
	27		74		-
Chlorides	14		133		56
	2.4		21		8
	5		35		-
Sulfates	328		1,430		335
	33		87		63
	89		193		-
Discharge (cfs)	10,290		2,766		15,200
	357		9		400
	2,048		379		2,677

* U.S.G.S. water supply paper 1523.

1/ Multiple entries represent maximum, minimum, and weighted values.

2/ 1 mile southeast of town of Green River.

3/ 12 miles upstream from 1/ above.

4/ 1/2 mile below Flaming Gorge Dam.

Table E-3. Waste Disposal Facilities in Blacks Fork Basin

Community	Estimated Population Served	Treatment	Discharged to
Diamondville	--	Individual facilities	--
Ft. Bridger	--	Individual facilities	--
Frontier	--	Individual facilities	--
Granger	160	Septic tank	Blacks Fork
Kemmerer	2030	None but oxidation pond planned	Hams Fork
Lyman	100	Oxidation pond	Blacks Fork
Mt. View	400	Oxidation pond	Smiths Fork

CONSTRUCTION PHASE OF PROJECT

Limited housing accommodations are available within a 50-mile radius of the construction area to serve the contractors' employees during the construction phase of the project. Under these conditions a temporary construction camp may be necessary. A sanitary survey of all proposed construction camp sites by the State Department of Public Health would be desirable to assist in solving of problems that may have a public health significance.

Adequate sanitary facilities to serve temporary camps as well as permanent housing should be included with construction plans so as to eliminate pollution of surface waters. The establishment of a trailer park or temporary construction camp in a National Forest requires a special use permit from the Forest Service to cover the sites and plan approval by the Wyoming State Department of Public Health to insure the installation of proper sanitary facilities.

FUTURE SITUATION

Project development will help to improve the local economy and increase the opportunity for residents to enjoy a higher standard of living. Some of the more important factors in creating a healthful environment include the development of safe and ample water supplies, proper waste disposal facilities, and insect and rodent control measures. District Health Unit No. 2 of the Wyoming State Department of Health with headquarters in Rock Springs is available to assist the inhabitants of the project area on environmental health problems. The Wyoming State Department of Health headquarters staff provides supplementary public health services in Uinta County.

Recreation facilities are planned for all reservoirs. In addition to recreational activities on the reservoirs, fishing will be enhanced by the series of fish ponds proposed in the 8-mile stretch of the Blacks Fork below the potential Meeks Cabin Dam and reservoir. Existing resorts in the project area provide limited recreational activities. In addition to the

planned development of recreational activities in the overall water resource development plan, the spontaneous occurrence of recreational areas following the filling of reservoirs necessitates the need for adequate sanitary facilities and safety measures as protection against health hazards.

Water supplies and sanitary facilities at all recreational areas should be constructed and maintained in accordance with the Wyoming State Department of Public Health standards.

The dissolved solids concentration in Blacks Fork downstream of the proposed project is expected to increase over present levels, primarily due to the contemplated reuse of irrigation return flows which already have high concentrations. However, no water uses are expected to develop that would be affected by this level of dissolved solids. Blacks Fork will flow into the reservoir on Green River formed by Flaming Gorge Dam. Considering the relative flows and relative water quality of Blacks Fork and Green River, the effect of the future water quality of Blacks Fork on the Green River is expected to be slight.

STREAM FLOW REGULATION FOR WATER QUALITY CONTROL

On the basis of a preliminary evaluation of the probable future economy of the Lyman area, there appears to be little likelihood that downstream beneficiaries of water quality control will locate below the project area. Approximately 13,100 acre-feet of irrigation return flow will be developed by the operation of the proposed project and this supply will be used for irrigation in the lower portion of the Basin. The quality of these return flows is expected by the Bureau of Reclamation to be suitable for the downstream irrigation.

The water needs of the future economic development downstream of the project area are expected to be met by the storage in Fontenelle Reservoir on the Green River. Between the area of expected limited municipal and industrial growth near Granger and Westvaco and the mouth of Blacks Fork, there does not appear to be any need for higher quality water. The wastes from these developments are not expected to affect any other uses of the stream. Therefore, the need for storage of water in either Meeks Cabin or China Meadows Reservoirs for the purpose of stream flow regulation for water quality control is not apparent at this time.

SECTION F. VECTOR EVALUATION OF THE PROPOSED BUREAU OF RECLAMATION LYMAN PROJECT, UINTA COUNTY, WYOMING

NATURE AND EXTENT OF MOSQUITO AND OTHER VECTOR PROBLEMS

In September 1959 and May and July 1960, field reconnaissances of the Lyman Project area were conducted to determine (1) the kinds and abundance of mosquitoes and other vectors in the area; (2) existing sources of these vectors; (3) effect of the proposed project on vector problems; and (4) measures which might be incorporated into the design, construction, and operation of the project to minimize vector production. Based on field observations, mosquitoes appeared to be the vectors of major public health importance in the area. At several locations in the project area deer flies and horse flies were prevalent and annoying and biting specimens were collected for identification.

PUBLIC HEALTH AND SOCIO-ECONOMIC IMPORTANCE

Encephalitis, commonly known as sleeping sickness or brain fever, is now the most important mosquito-borne disease in the United States and in the area in which the proposed project will be located. Mosquitoes transmit the encephalitis viruses among birds and from them to humans and horses. There are no effective chemotherapeutic measures for preventing or treating human cases, and some individuals, particularly children, who recover from encephalitis often suffer permanent mental disability.

Records of the U. S. Department of Agriculture show that equine encephalitis cases occurred in Uinta County, Wyoming and/or neighboring counties during 11 years of the 17-year period, 1939 through 1955, for which records are available. During several years, Uinta County had an incidence in excess of 5 encephalitis cases per 1,000 horses.

Although no human outbreaks of encephalitis have been reported in Uinta County, the records of equine encephalitis indicate that the viruses of this disease are present in the area. Since encephalitis virus is active in the area and Culex tarsalis, the primary vector, is present, future outbreaks of the disease may occur among horses and humans.

The vicious-biting Aedes mosquitoes may create public health problems by interfering with the healthful outdoor activities of both children and adults during the summer months. Individuals, particularly children, frequently require medical attention and sometimes hospitalization for treatment of secondary infections and allergic reactions resulting from mosquito bites.

In addition to their public health importance, large numbers of biting mosquitoes also cause severe economic losses by lowering meat and milk production, by reducing the efficiency of agricultural and industrial workers, by interfering with recreational enterprises, and by lowering the value of real estate.

Several other groups of aquatic insects may be produced in sufficient numbers in habitats associated with water resource projects to create public health and economic problems. Deer flies and horse flies are often produced along the margins of impoundments and in seeps and marshes in irrigated areas. These insects are vicious biters of both man and livestock and are sometimes involved in the transmission of disease such as tularemia and anthrax. Several species of small gnats of the family Heleidae are vicious biters and often produce severe reactions and vesicular lesions. These gnats are produced in damp acreas of many irrigated valleys as well as alkaline marshes and other wetland areas. Black flies plague both man and livestock with their irritating and painful bites. They normally breed in streams, but are sometimes produced in large numbers in irrigation conveyance systems, particularly drop structures and other water control devices where the flow is relatively fast.

Vectors of terrestrial origin, including arthropods such as ticks, mites, fleas, and flies, and rodents such as ground squirrels, chipmunks, and mice may be important at recreational sites along the shores of reservoirs. In addition to the irritation, discomfort, and annoyance caused by the arthropod bites, the public health importance of these vectors involves a number of human diseases including Rocky Mountain spotted fever, Colorado tick fever, relapsing fever, tick paralysis, dysentery, typhoid, tularemia, typhus, and plague.

VECTOR SPECIES COLLECTED IN THE AREA

Mosquitoes.--Aedes increpitus, Aedes vexans, and Aedes dorsalis were the predominant mosquito species collected during the surveys. Prolific production of these vicious-biting mosquitoes was observed in flooded meadows and marshy roadside ditches in the vicinity of Millburne and Robertson in May 1960. In July 1960, prolific production of A. vexans was found also in overflow pools and other undrained surface depressions along Black Fork in the vicinity of Millburne. Larvae of Culex tarsalis, the primary vector of encephalitis in the West, were found in considerable numbers during July, in association with larvae of Culiseta inornata, a suspect enzootic vector of encephalitis. The major sources of C. tarsalis and C. inornata appeared to be seepage area, marshy roadside ditches, and flooded borrow pits along secondary roads where drainage is blocked by unculverted turnins which provide acess to farmsteads and fields.

Deer Flies and Horse Flies.--Adults of Chrysops discalis, a vicious-biting deer fly, and Tabanus Lineola, a highly annoying horse fly, were collected at various localities in the project area. In addition to the annoyance resulting from the bites of these flies, C. discalis is considered an important vector of tularemia in western North America. Marshes and seepage areas prevalent in the project area appear to be favorable for the production of deer flies and horse flies.

GENERAL RELATIONSHIPS BETWEEN IRRIGATION AND VECTOR PROBLEMS

The production of mosquitoes and other aquatic insects of public health importance is widespread in many irrigation areas. Natural breeding places occur in most irrigated areas, but usually the man-made mosquito sources are

frequently caused by the same faulty irrigation and drainage practices that cause serious soils and water problems such as excessive water losses, water-logging, erosion, salt and alkali accumulations, damage to soil structure, leaching of plant nutrients, and reduced crop yeilds. Mosquito sources commonly associated with irrigation may be grouped into three principal categories: (1) those related to storage reservoirs; (2) those related to irrigation conveyance systems; and (3) those related to use of irrigation water on the farm and the disposal of excess water.

The condi tions associated with storage reservoirs which are conducive to mosquito production include emergent vegetation and/or flotage and debris in shallow water areas and embayments that are protected from wave action; undrained depressions, borrow pits, sloghs, and swamps within the fluctuation zone; rising or constant pool levels which cause the water to remain in the marginal vegetation for more than four or five consecutive days during the mosquito breeding season; and marshy seeps below dams. It is often difficult to control mosquito production on a reservoir that has not been properly prepared prior to impounding. The principal preimpoundage preparation measures for mosquito control include: clearing of the reservoir basin; final removal of vegetation from the fluctuation zone prior to impounding; and drainage for depressions, sloughs, and swamps within the fluctuation zone. Of paramount importance is the fact that the maximum benefits from water level management for mosquito control can be realized only when the reservoir has been properly prepared. Several phases of water level control, particularly flood surcharge, constant level pool, and cyclical fluctuation and/or seasonal recession can sometimes be adapted to irrigation storage reservoirs in order to minimize conditions favorable for mosquito production. A particular phase may be used primarily to destroy mosquito larvae, or it may be directedat vegetation or flotage favorable for mosquito production. A flood surcharge above the upper normal pool level for a few days in the spring prior to the mosquito breeding season followed by a sharp drawdown is effective in stranding objectionable flotage. The invasion of marginal vegetation can be limited by holding the reservoir at a constant level during the early spring growth period. This phase is especially important since it will increase the effectiveness of subsequent fluctuation or recession. Seasonal water level recession used alone or in combination with periodic fluctuation is a very effective control measure since it provides a clean shoreline which is unfavorable for mosquito production.

When unlined irrigation canals and laterals are constructed in previous material, a large percentage of the water is lost by seepage through the beds and banks. In areas with poor underdrainage, these seepage losses in combination with deep percolation from irrigated lands often result in marshy seeps and ponded water in roadside ditches, borrow pits, and numerous other undrained depressions. Such habitats, which occur on both irrigable and nonirrigable lands, produce tremendous numbers of mosquitos, especially C. tarsalis, the common encephalitis vector. Large numbers of Aedes mosquitoes are also produced in seepage areas that have fluctuating water levels. In addition to creating conditions favorable for prolific mosquito production, seepage also causes excessive loss of irrigation water and serious damage to

valuable agricultural lands. Mosquitoes are also produced in various other types of water areas associated with irrigation conveyance systems. Typical examples are ponded areas where canals block natural drainageways, residual water in turnout structures, stilling basins and other hydraulic structures, and pools caused by leakage from turnouts and other water control structures. Although such habitats are generally of minor importance in comparison with those caused by seepage and the numberous other breeding places that occur in irrigated areas, they also contribute to the overall mosquito problem.

In many irrigated areas, the most important mosquito sources are those associated with the use of water on the farm and the disposal of excess water. Studies on several operating irrigation projects have shown that mosquito sources in this category are usually caused by poor irrigation and drainage practices that also result in serious agricultural problems, including reduced crop yields. These practices include inadequate land preparations; use of field layouts and irrigation methods that do not fit land, crops, and water supply; application of water in excess of crop requirements; inadequate drainage systems for disposal of excess water, and poor maintence of distribution and drainage systems. All of these practices contribute to the development of both "on-field" and "off-field" aquatic habitats which are favorable for prolific mosquito production. Permanent and semipermanent aquatic habitats produce large number of C. tarsalis, and intermittently flooded areas produce tremendous numbers of Aedes mosquitoes.

Mosquito sources on irrigated fields have been found to occur most often on those used for pastures, hay meadows, and other close-growing crops. In order for the aquatic stages to mature and produce adult mosquitoes, ponded water must be present for at least four or five days. Observations in several irrigated areas have shown that when water is ponded on fields long enough to produce mosquitoes, the better forage grasses and legumes are frequently killed and replaced by undesirable wetland plants.

Heavy mosquito production also occurs in numberous "off-field" aquatic habitats. Many of the mosquito sources located outside irrigated fields are caused by improper disposal of excess water. Roadside ditches, borrow pits, depressions on wasteland, and numerous other undrained areas are flooded by excess irrigation water when farm and trunk drainage systems are inadequate. Such habitats produce large numbers of C. tarsalis and other mosquitoes of public health importance.

FACTORS RESPONSIBLE FOR MOSQUITO-PRODUCING HABITATS IN THE PROJECT AREA

It was observed that mosquito-producing habitats in the project area are largely associated with poor irrigation and drainage practices. In many cases, the meadows and pastures have not been leveled or graded. Many of these unleveled, hummocky meadows are irrigated by wild flooding and are inadequately drained, resulting in prolonged ponding which provides favorable conditions for the production of mosquitoes. Due to the inadequacy or lack of drainage facilities, excess runoff from the meadows collects in roadside

ditches, sloughs, marshes, and other undrained depressions creating numerous "off-field" aquatic habitats that produce tremendous numbers of mosquitoes. Seepage from unlined canals and the high water table resulting from excessive application of irrigation water also results in numerous aquatic habitats highly favorable for production of C. tarsalis and other irrigation mosquitoes.

During the period of high flows in the spring, low-lying areas adjacent to the streams and distribution canals are flooded. This condition also results in the production of large numbers of mosquitoes, particularly A. vexans, a highly annoying floodwater species. It was noted that many of the aquatic habitats producing tremendous numbers of mosquitoes in the project area could be eliminated by installation of culverts to provide drainage of roadside ditches and borrow areas and by other minor drainage work.

ANTICIPATED EFFECTS OF THE PROJECT ON VECTOR PROBLEMS

The reduction in flooding of lowland areas located downstream from the proposed reservoirs should result in a reduction in natural aquatic habitats which are favorable for the production of mosquitoes and other aquatic insects of public health importance. Portions of the reservoirs that have steep shores with little or no vegetation and are exposed to strong wave action will be unfavorable for the production of mosquitoes and other aquatic insects of public health importance. Mosquitoes and other aquatic insects of public health importance may be produced in tributary embayments and other marginal areas of the reservoirs where the topography is flat and the water is shallow, protected from wave action, and contains emergent vegetation or flotage. In such areas appropriate measures for prevention and control of aquatic vectors should be provided. The development of recreational and other public use areas at various locations along the shores of the reservoirs may result in the exposure of humans to vectors of terrestrial origin including arthropods such as ticks, fleas, flies, and rodents such as ground squirrels, chipmunks, and mice. In order to minimize public health hazards at waterside recreational areas, appropriate prevention and control measures for both aquatic and terrestrial vectors should be carried out.

The proposed lining of canals should minimize seepage areas which are favorable for mosquito production. Likewise, the proposed drainage should eliminate and prevent numerous mosquito sources. Additional measures of these types may be needed after the project is in operation. Since many of the more serious existing mosquito sources in the area are associated with poor irrigation and drainage practices employed by the water users, every effort should be made to encourage farmers to use improved irrigation and drainage methods to prevent and minimize mosquito sources.